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NATIONAL DAM SAFETY PROGRAM. FLOYD LAKE DAM (MO 30744), MISSISS--ETC(U)
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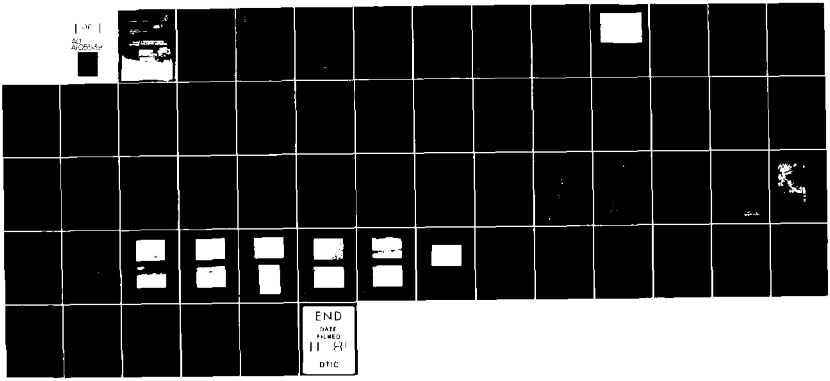

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This report was prepared under the National Program of Inspection of Non-Federal Dams. This report assesses the general condition of the dam with respect to safety, based on available data and on visual inspection, to determine if the dam poses hazards to human life or property.

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DEPARTMENT OF THE ARMY
ST. LOUIS DISTRICT, CORPS OF ENGINEERS
210 TUCKER BOULEVARD, NORTH
ST. LOUIS, MISSOURI 63101

REPLY TO
ATTENTION OF

LMSED-PD

SUBJECT: Floyd Lake Dam Phase I Inspection Report

This report presents the results of field inspection and evaluation of the Floyd Lake Dam (MO 30744).

It was prepared under the National Program of Inspection of Non-Federal Dams.

This dam has been classified as unsafe, emergency by the St. Louis District as a result of the application of the following criteria:

a. Spillway will not pass a 10-year frequency flood without overtopping of the dam. The spillway is, therefore, considered to be unusually small and seriously inadequate.

b. Overtopping could result in dam failure.

c. Dam failure significantly increases the hazard to life and property downstream.

SUBMITTED BY: SIGNED — Chief, Engineering Division — 24 DEC 1980 — Date

APPROVED BY: SIGNED — Colonel, CE, District Engineer — 24 DEC 1980 — Date

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FLOYD LAKE DAM

Washington County, Missouri

Missouri Inventory No. 30744

Phase I Inspection Report

6 **National Dam Safety Program,**

Floyd Lake Dam (MØ 3Ø744), Mississippi - Kaskaskia - St. Louis Basin, Washington County, Missouri. Phase I Inspection Report.

Prepared by

Woodward-Clyde Consultants

Chicago, Illinois

15 DACW43-8Ø-C-ØØ39

9 Final rept.,

10 Richard G. /Berggreen

Leonard M. /Krazynski

Under Direction of

St Louis District, Corps of Engineers

12 56

for

Governor of Missouri

11 Nov[redacted]8Ø

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PREFACE

This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams for Phase I Investigations. Copies of these guidelines may be obtained from the Office of the Chief of Engineers, Washington, D. C., 20314. The purpose of a Phase I investigation is not to provide a complete evaluation of the safety of the structure nor to provide a guarantee on its future integrity. Rather the purpose of the program is to identify potentially hazardous conditions to the extent they can be identified by a visual examination. The assessment of the general condition of the dam is based upon available data (if any) and visual inspections. Detailed investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I investigation; however, the investigation is intended to identify the need for more detailed studies. In view of the limited nature of the Phase I studies no assurance can be given that all deficiencies have been identified.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with any data which may be available to the inspection team. In cases where the reservoir was lowered or drained prior to inspection, such action removes the normal load on the structure, as well as the reservoir head along with seepage pressures, and may obscure certain conditions which might otherwise be detectable if inspected under the normal operating environment of the structure.

It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through frequent inspections can unsafe conditions be detected, so that corrective action can be taken. Likewise continued care and maintenance are necessary to minimize the possibility of development of unsafe conditions.

PHASE I REPORT
NATIONAL DAM SAFETY PROGRAM

Name of Dam	Floyd Lake Dam
State Located	Missouri
County Located	Washington
Stream	Unnamed Tributary of Old Mines Creek
Date of Inspection	18 July 1980

Floyd Lake Dam, Missouri Inventory Number 30744, was inspected by Richard Berggreen (engineering geologist), Leonard Krazynski (geotechnical engineer), John Seymour (geotechnical engineer) and Sean Tseng (hydrologist).

The dam inspection was made following the guidelines presented in the "Recommended Guidelines for Safety Inspection of Dams". These guidelines were developed by the Chief of Engineers, U.S. Army, Washington, D.C., with the help of federal and state agencies, professional engineering organizations, and private engineers. The resulting guidelines represent a consensus of the engineering profession. These guidelines are intended to result in an expeditious identification of those dams which may pose hazards to human life and property, based on available data and a visual inspection. In view of the limited nature of the study, no assurance can be given that all deficiencies have been identified.

The dam has been classified by the St Louis District, Corps of Engineers (SLD), as having a high hazard potential; we concur with this classification. The SLD estimated damage zone length extends approximately eight miles downstream of the dam. Within the potential downstream damage zone are 4 dwellings within the first mile and the town of Old Mines, approximately 2 mi downstream.

The dam is classified small due to its 50 ac-ft storage capacity. The dam is 21 ft high. The classification for small size dams is based on a height between 25 and 40 ft or a storage capacity between 50 and 1000 ac-ft.

The visual inspection and available information indicate the dam is in generally poor condition. The principal deficiencies noted were the inadequate spillway capacity, potential erosion at the toe of the dam by the flow in the discharge channel, and very dense vegetation on the downstream slope of the dam, obscuring the face from a thorough inspection.

Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is a deficiency that should be rectified.

Hydraulic and hydrologic analyses indicate that the dam will be overtopped by the 10 percent probability-of-occurrence event (10-yr flood), and by a flood of greater than 5 percent of the PMF event. The PMF is defined as the flood event that may be expected to occur from the most severe combination of critical meteorological and hydrologic conditions that are reasonably possible in the region.

On the basis of the proximity of the town of Old Mines downstream of this dam, it is recommended that 100 percent of the Probable Maximum Flood (PMF) be used as the spillway design flood.

The following remedial measures and additional studies are recommended for Floyd Lake Dam:

1. Prepare a hydraulic/hydrologic analysis, and design spillway and discharge channel systems capable of passing the PMF without overtopping the embankment.

2. Evaluate the feasibility of the relocation of the downstream discharge channel away from the toe of the dam, or provide adequate erosion protection.

3. Remove trees and other obstructions from the downstream channel. Also evaluate removal of trees and vegetation from the downstream face of the dam. Removal of large trees should only be done under the guidance of an engineer experienced in the design and construction of dams. Indiscriminate clearing could jeopardize the safety of the dam.

4. Perform seepage and stability analyses to meet the requirements of the "Recommended Guidelines for Safety Inspection of Dams".

5. Develop a program of periodic inspections to identify necessary maintenance. This inspection program should include but not be limited to:

   a. Evaluation of erosion in the spillway and discharge channel;

   b. Inspection of the embankment for signs of slope instability such as cracking or slumping;

   c. Monitoring seepage to identify changes in seepage volume or turbidity of seepage water.

Maintenance should also include controlling vegetation on the face of the dam. Records should be kept of the inspections and any required maintenance.

The analyses and remedial measures should be performed by an engineer experienced in the design and construction of earth dams.

It is recommended the owner take action on these recommendations without undue delay to preclude deterioration which could lead to development of hazardous conditions. Action regarding the spillway capacity should be taken immediately.

WOODWARD-CLYDE CONSULTANTS

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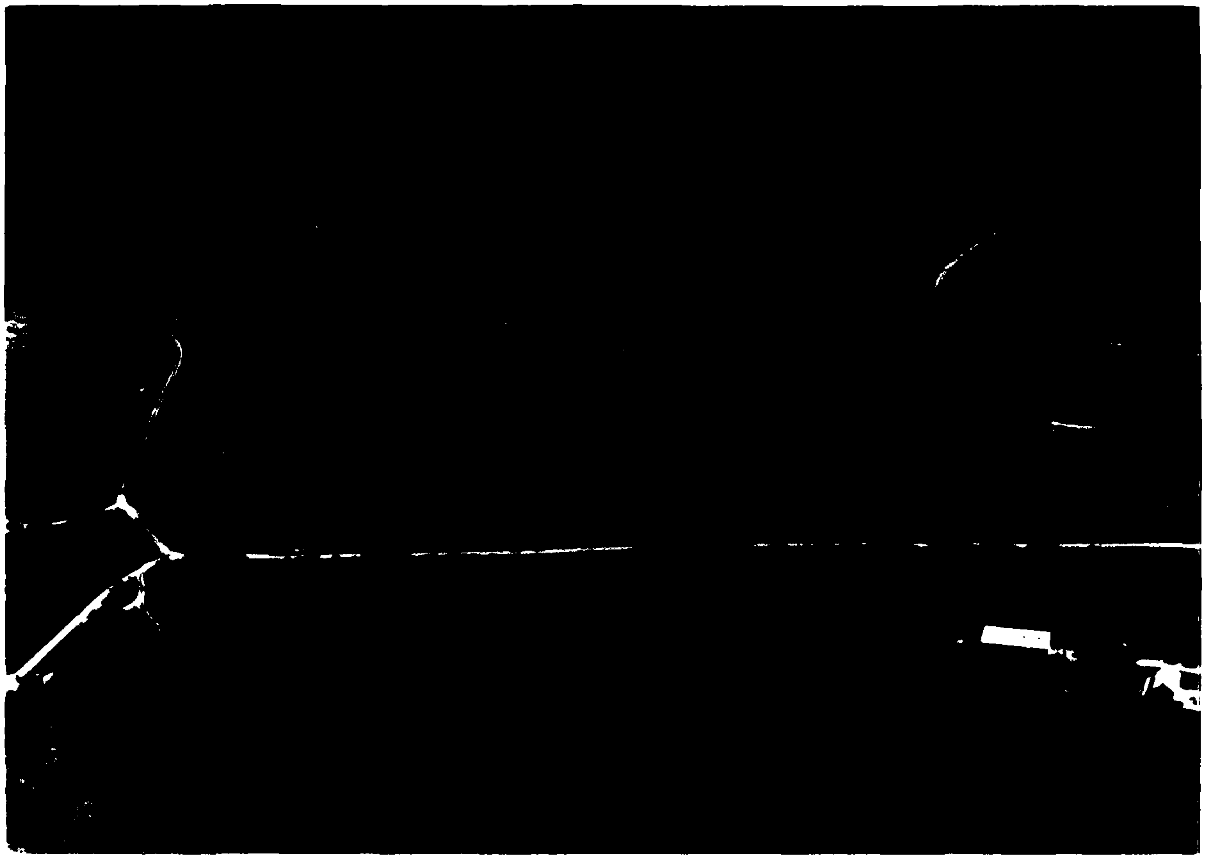

OVERVIEW
FLOYD LAKE DAM

MISSOURI INVENTORY NUMBER 30744

PHASE I INSPECTION REPORT

NATIONAL DAM SAFETY PROGRAM

FLOYD LAKE DAM, MISSOURI INVENTORY NO. 30744

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PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
FLOYD LAKE DAM, MISSOURI INVENTORY NO. 30744

SECTION 1
PROJECT INFORMATION

1.1 General

a. **Authority.** The National Dam Inspection Act, Public Law 92-367, provides for a national inventory and inspection of dams throughout the United States. Pursuant to the above, an inspection was conducted of Floyd Lake Dam, Missouri Inventory Number 30744.

b. **Purpose of Inspection.** "The primary purpose of the Phase I investigation program is to identify expeditiously those dams which may pose hazards to human life or property... The Phase I investigation will develop an assessment of the general condition with respect to safety of the project based upon available data and a visual inspection, determine any need for emergency measures and conclude if additional studies, investigations and analyses are necessary and warranted" (Chapter 3, "Recommended Guidelines for Safety Inspection of Dams").

c. **Evaluation criteria.** The criteria used to evaluate the dam were established in the "Recommended Guidelines for Safety Inspection of Dams", Engineering Regulation No. 1110-2-106 and Engineering Circular No. 1110-2-188, "Engineering and Design National Program for Inspection of Non-Federal Dams", prepared by the Office of Chief of Engineers, Department of the Army, and "Hydrologic/Hydraulic Standards, Phase I Safety Inspection of Non-Federal Dams", prepared by the St Louis District, Corps of Engineers (SLD). These guidelines were developed with the help of several federal agencies and many state agencies, professional engineering organizations, and private engineers.

1.2 Description of Project

a. **Description of dam and appurtenances.** Floyd Lake Dam is an earth dam constructed of residual clay soil with an outer protective mantle of gravel. The dam was constructed to impound water for an adjacent barite ore processing plant. The mine and processing plant are currently abandoned. The dam impounds water and an undetermined amount of fine tailings. The reservoir is currently used for recreation.

The spillway is located at the right (eastern) abutment, is vegetated by grass and weeds, and is crossed by a gravel road. The downstream discharge channel flows north from the spillway and crosses another gravel road. The channel continues northwest along the toe of the dam (see Fig A-1, Appendix A). Another spillway was originally located at the west end of the dam (left abutment). This spillway has been filled and is no longer identifiable. An abandoned discharge channel for this spillway flows northeastward along the toe of the dam to near the maximum section of the dam where it merges with the existing downstream discharge channel (Fig A-1, Appendix A). The combined channels flow northward from there along the original stream channel toward the town of Old Mines.

There are two abandoned tailings dams located upstream of the impoundment. The pond areas for these dams are almost totally filled with tailings, are heavily vegetated, and are essentially reclaimed by nature (Photos 1 and 2).

b. **Location.** Floyd Lake Dam is located on an unnamed tributary of Old Mines Creek, approximately 4 mi north of the town of Potosi, in Washington County Missouri, in the southernmost portion of Mineral Land Survey #3039, T38N, R3E, USGS Potosi 7.5 minute quadrangle map (Fig 1).

c. **Size classification.** The dam is classified as small due to its approximately 50 ac-ft storage capacity. The dam is 21 ft high. The small size classification is based on a height between 25 and 40 ft or a storage capacity between 50 and 1000 ac-ft.

d. **Hazard classification.** The dam has been classified by the St Louis District, Corps of Engineers (SLD), as having a high hazard potential; we concur with this classification. The SLD estimated damage zone length extends approximately eight miles downstream of the dam. Located within this zone are four dwellings in the first mile (Photo 3), and the town of Old Mines, approximately two miles downstream.

e. **Ownership.** The dam is reportedly owned by Mr F. W. Floyd. Correspondence should be addressed to Mr F. W. Floyd, Potosi, Missouri 63664.

f. **Purpose of dam.** The dam was originally constructed to impound water used in the adjacent barite ore processing mill. Later, it held water recycled from the barite ore tailings impoundments upstream from the reservoir. The barite processing mill is abandoned and the reservoir impounded by the dam is currently used for recreational purposes.

g. **Design and construction history.** Information on the design and construction history of the dam was obtained from interviews with Mr Dall Groves and Mr F. W. Floyd, both of Potosi, Missouri.

The dam was built in 1946 to act as the clearwater pond for a barite ore mine. The mine was in operation from 1946 until 1957. For construction of the dam, the land was first cleared and a trench (of undetermined size) was excavated, and filled with compacted clay soil. The excavation reportedly did not reach bedrock. The dam was then built from locally obtained residual clayey soil. No records were available documenting the compaction of either the clay cutoff trench or the embankment of the dam. The downstream slope was reportedly constructed at approximately 2(H) to 1(V), and the upstream slope was constructed at approximately 3(H) to 1(V). The dam was then covered with gravel waste (chat) from the barite mill presumably for erosion protection, improvement of trafficability of the crest, and to inhibit burrowing by animals.

h. **Normal operational procedures.** The dam is currently abandoned and there are no operating facilities at this site.

1.3 Pertinent Data

a. **Drainage area.** Approximately 0.37 mi^2

b. **Discharge of damsite.**

Maximum known flood at damsite	Unknown
Warm water outlet at pool elevation	N/A
Diversion tunnel low pool outlet at pool elevation	N/A
Diversion tunnel outlet at pool elevation	N/A
Gated spillway capacity at pool elevation	N/A
Gated spillway capacity at maximum pool elevation	N/A
Ungated spillway capacity at maximum pool elevation	100 ft^3/sec
Total spillway capacity of maximum pool elevation	100 ft^3/sec

c. **Elevations (ft above MSL).**

Top of dam	908.3 to 910.9
Maximum pool - design surcharge	N/A
Full flood control pool	N/A
Recreation pool	906.3
Spillway crest (gated)	N/A
Upstream portal invert diversion tunnel	N/A
Downstream portal invert diversion tunnel	N/A
Streambed at centerline of dam	Unknown
Maximum tailwater	N/A
Toe of dam at maximum section	888.4

d. **Reservoir.**

Length of maximum pool	500 ft
Length of recreation pool	500 ft
Length of flood control pool	N/A

e. **Storage (acre-feet).**

Recreation pool	37
Flood control pool	N/A

Design surcharge	N/A
Top of dam	50

f. **Reservoir surface (acres).**

Top of dam	7.5
Maximum pool	7.5
Flood control pool	N/A
Recreation pool	6
Spillway crest	6

g. **Dam.**

Type	Equipment-rolled earth and chat
Length	1250 ft
Height	21 ft (maximum section)
Top width	18 to 22 ft
Side slopes	Downstream 2(H) to 1(V);
	Upstream unknown (reported to be 3(H) to 1(V))
Zoning	None
Impervious core	None
Cutoff	Trench filled with compacted clay
Grout curtain	None

h. **Diversion and regulating tunnel.**

Type	None
Length	N/A
Closure	N/A
Access	N/A
Regulating facilities	N/A

i. **Spillway.**

Type	Irregular, earth with grass and gravel

Length of weir	45 ft
Crest elevation	906.3 ft (MSL)
Gates	None
Upstream channel	None
Downstream channel	Brushy, grass-lined, with some portions eroded to bedrock

j. **Regulating outlets.** Four assorted pipe culverts under the upstream-most road which acts as the spillway. Pipes are apparently blocked. Two 4-in., one 6-in. and one 8-in. diameter pipes.

SECTION 2
ENGINEERING DATA

2.1 Design

No design drawings or records were found for this dam. Mr Dall Groves, a former manager of the mine, and Mr Floyd, the current owner, provided all design data included in this report. A formal design by an engineer experienced in the design and construction of dams was apparently not made for this dam.

2.2 Construction

The dam was built in 1946, according to Mr Groves. The dam has a compacted clay key that reportedly does not extend to bedrock. The dam is constructed from locally obtained residual stoney clay (CL to CH) and compacted using vehicle tires and tracks. It has an outer mantle of chat. The main existing spillway is located on the east end of the dam (right abutment). A former (reported) auxiliary spillway at the west end has been subsequently filled with chat, presumably in an effort to maintain a dry roadway.

2.3 Operation

No operating records were available for this dam. Mr Groves has indicated that a major rainstorm on June 29, 1957 did not damage the dam as the dam had two operating spillways which successfully passed the flood. Following that storm, the spillway at the west end of the dam was filled (date unknown) to the elevation of the dam crest. Operations at the dam and mill were terminated in 1957.

2.4 Evaluation

a. **Availability.** The available engineering data were limited to the recollections of a former manager of the mining operation which used the dam, and to the present owner of the dam.

b. **Adequacy.** The available information is insufficient to evaluate the design of Floyd Lake Dam. Seepage and stability analyses comparable to the requirements of the guidelines are not on record. This is a deficiency which should be rectified. These seepage and stability analyses should be performed for appropriate loading conditions (including earthquake loads) and made a matter of record. These analyses should be performed by an engineeer experienced in the design and construction of dams.

c. **Validity.** There is no reason to question the validity of the information obtained from Mr Groves or Mr Floyd. The information is not in conflict with the conditions observed in the field.

2.5 Project Geology

The dam site lies on the northern flank of the Ozark structural dome. The regional dip is to the north. The bedrock in the area consists of Cambrian age Eminence and Potosi dolomite formations (Fig 4). The Potosi Formation is a light gray, medium-to fine-grained dolomite and typically contains an abundance of quartz druse characteristic of chert-bearing formations. The Eminence Formation comformably overlies the Potosi Formation, and is similar in appearance, but generally contains less quartz and chert. Large caves and springs are found in the Eminence Formation in parts of Missouri. Although solution activity was not noticed in the area, a possible spring was found near the right abutment of the dam (see Fig A-1 and Section 3.1.e.).

The soil at the dam site is a dark red-brown, stoney, plastic, residual clay (CL-CH), characteristically developed on the Potosi Formation. This soil is locally overlain by a thin loess profile (2 to 5 ft) consisting of clayey silt (ML). The soils in this area are mapped on the Missouri General Soils Map as Union-Goss-Gasconade-Peridge Association.

The Cabanne Fault, an east-west trending branch of the Big River Fault system, is mapped approximately 5 mi south of the dam. The fault is approximately 12 mi long, is mapped as north side down, and is within the Potosi and Eminence Formations at the surface. The Aptus Fault, a 15 mi long northwest-southeast trending branch of the Big River Fault system, is mapped approximately 5 mi west of the site. The Aptus fault is mapped as southwest side down, and is mapped within the Potosi and Eminence Formations at the surface. The faults are likely Paleozoic in age, and are not considered to be in a seismically active area. The faults are not considered to pose a significant hazard to the dam.

SECTION 3
VISUAL INSPECTION

3.1 Findings

a. General. The dam was inspected on 18 July 1980, without an owner's representative present. The inspection indicated the dam is in generally poor condition.

b. Dam. The dam is constructed of a gravelly residual clay (CL-CH) with a chat mantle of unknown thickness over the entire dam. The dumping of the chat has created irregular low ridges along the upstream and downstream edges of the dam crest.

A gravel road runs along the dam crest. The dam crest appears to be relatively level and ranges in width from about 18 to 22 ft. The chat ridges that have been deposited on the upstream and downstream edges of the road are generally higher than the road but are irregular (Fig 3). The alignment of the dam crest was apparently not disturbed although the crest is not straight (Photos 4 and 5). A bend has been identified in the dam crest, the eastern half of the dam being farther north than the western half. If this bend in the alignment of the dam crest was due to a lateral shift of this magnitude, it would probably have caused a dam failure. It should be noted that dams built for the barite ore mines in this area are often not surveyed and may be constructed with an irregular alignment. This offset, therefore, is probably the way the dam was originally built and it has not undergone significant deformation.

An 1/8-in. wide crack approximately 35 ft long, was noted running parallel to the dam crest on the northern (downstream) edge of the road (Fig A-1 and Photo 6). It was apparently shallow (a few inches) but the depth could not be accurately determined. The crack was linear and there was no difference in elevation between the two sides. The assessment made during our visual inspection was that the crack was probably caused either by minor settlement or shrinkage, as opposed to slope instability.

The dam was constructed with a 2(H) to 1(V) downstream slope and approximately a 3(H) to 1(V) upstream slope (as reported by Mr Groves). Both faces of the dam are now heavily vegetated with weeds, thick brush and mature trees (Photos 4 and 5). Slope movement, such as slumps, or erosion on the dam face could not be identified as the slopes were largely obscured from view by the thick vegetation. There is no riprap present on the dam.

Seepage was noted along the dam toe (Photo 7). The total seepage at the time of our inspection was about 5 gal/min and did not appear to be transporting any soil particles.

Seepage areas could be seen near the toe of the eastern one-third of the downstream face but vegetation obscured much of the downstream face. The ground at the toe of the western half of the dam is very wet and spongy and is vegetated with swamp grasses and trees. Specific points of seepage, however, could not be accurately observed due to the dense vegetation.

The foundation soil for the dam is a red to brown, residual stoney clay formed on dolomite bedrock. The bedrock is apparently Eminence Formation, as indicated by the relatively small amounts of quartz druse in the soil. There was no unusual cracking or bulging of the soil beyond the toe of the dam, suggesting that the foundation soils are stable. Evidence of sinkholes was not identified on or around the dam. Animal burrows could not be identified on the dam face due to the thick vegetation, but adjacent grass fields contained numerous small-diameter burrows.

The dam apparently has a low erosion potential, due to the thick vegetative growth on its faces. If the vegetation is totally stripped to the original chat mantle, the chat would be moderately to highly susceptible to erosion.

c. **Appurtenant structures.** The spillway is located at the eastern (right) abutment. It is crossed by a gravel road which acts as a weir controlling flow out of the impoundment. The spillway is partially covered with grass and partially lined by gravel where the road crosses it. Four pipe culverts run under the road and their apparent function was to act as a reservoir level regulator. Originally, the lake level appears to have been maintained about 3 ft below the crest. These pipe culverts were only visible at the downstream end of the spillway and were dry (Photo 8). As no control valves were identified, it is assumed that these pipe culverts are clogged at the upstream end and are no longer functioning.

The dam was reportedly originally constructed with two spillways, one at each abutment. The spillway at the west abutment was no longer identifiable at the time of our inspection and appears to have been filled with chat, presumably in an effort to maintain a dry roadway.

d. **Reservoir area.** Immediately upstream of the reservoir are two abandoned tailings dams approximately 40 ft in height (Photos 1, 2 and 5). The downstream slopes are estimated at 35 degrees which is typical of tailings dams in this area. The impoundment areas are almost totally fileld with fine-grained tailings and are heavily vegetated.

The remaining area around the reservoir has slopes of less than 5(H) to 1(V). Pasture and farm fields surround the reservoir and dam. No evidence of potentially unstable slopes, other than the very steep slopes of the upstream tailings ponds, was noted during the field inspection.

Since the construction of Floyd Lake Dam, construction of two upstream tailings dams has taken place. This has added fine grained tailings to the Floyd Lake reservoir at a higher rate than normal sedimentation rates. The original lake depth was approximately 15 to 18 ft. Since the spillway outlet pipes have become clogged, the lake level has risen perhaps 1 to 2 ft.

e. **Downstream channel.** The downstream discharge channel flows north from the gravel road at the spillway location, through a low area (Photo 9), crosses another gravel road, and then flows northwest along the toe of the dam (Fig A-1, Appendix A). Where the downstream discharge channel crosses the second gravel road, two 12-in. diameter culverts pass under the road (Photo 10). Flood flows which could not be accommodated by these culverts would flow across the road. The discharge end of the culverts is partially protected from erosion by coarse tailings waste (bullrock). The downstream discharge channel along the toe of the dam is heavily vegetated (Photo 11) and could easily become obstructed during flood flows. The downstream discharge channel is at or near bedrock so no significant deepening of the channel by erosion is expected. However, substantial lateral erosion could occur along the banks of the channel particularly if the channel becomes obstructed by fallen trees. This erosion could undercut the toe of the dam, reducing the slope stability.

Flow from what appeared to be a small spring at the soil-bedrock contact was noted in the downstream discharge channel, below the two 12-in. culverts (Photo 7 and Fig A-1, Appendix A). The elevation of the spring relative to the pond elevation suggested it was not due to seepage from the reservoir. Flow at the time of our inspection was of the order of 2 gal/min.

3.2 Evaluation

The visual inspection indicated that the dam is in generally poor condition. The lack of maintenance at this facility has created conditions that are detrimental to the dam's safety because the very thick vegetation inhibits proper inspection of the dam. The amount and maturity of the vegetation in the downstream channel and on the dam face is considered a deficiency. Removal of large trees should be evaluated by an engineer experienced in the design and construction of dams. Indiscriminate clearing could jeopardize the safety of the dam. After removal of the major vegetation the dam face and points of seepage should be re-inspected. The spillway is irregular and moderately erodible although the bedrock surface appears to be at a rather shallow depth. The spillway should be enlarged and, if necessary, protected against erosion. The downstream discharge channel is obstructed by a gravel road which would tend to divert heavy flows away from the dam and toward the field beyond the toe of the dam. The downstream discharge channel should be re-routed away from the toe of the dam, or the toe and the channel should be protected against erosion. The current total seepage at the time of our inspection was approximately 5 gal/min. The heavy vegetative growth obscures the locations of some points of seepage. This condition should be rectified, so the amount and turbidity of the seepage can be periodically checked.

SECTION 4
OPERATIONAL PROCEDURES

4.1 Procedures

No operating procedures currently exist at this facility as the dam has been abandoned.

4.2 Maintenance of Dam

At the present time there are no formal maintenance procedures in effect at this facility. It does not appear that the dam has been maintained for over 20 years, based on vegetation on the dam. According to Mr Groves, during the time the barite mill was operating (1946 to 1957), vegetation was kept off the dam faces and spillways, and rodents were controlled.

4.3 Maintenance of Operating Facilities

There are no facilities requiring operation at this dam.

4.4 Description of Any Warning System in Effect

The visual inspection did not identify any warning system in effect at this dam.

4.5 Evaluation

There is currently no identified plan for periodic inspections nor performance of maintenance. This is considered a deficiency.

Consideration should be given to controlling vegetation on the dam, as roots could provide potential piping paths through the embankment. Excessive tree and shrub growth interferes with proper inspection of the dam. Removal of large trees should be done under the guidance of an engineer experienced in the design, construction, and maintenance of dams. Indiscriminate clearing of trees could jeopardize the safety of the dam.

The feasibility of a practical warning system should be evaluated to alert downstream residents and traffic, should potentially hazardous conditions develop during periods of heavy precipitation.

SECTION 5
HYDRAULIC/HYDROLOGIC

5.1 Evaluation of Features

a. Design data. No hydrologic or hydraulic information was available to aid in the evaluation of this dam. Pertinent dimensions of the dam were surveyed in July 1980. Other information was obtained during the field inspection or estimated from topographic maps. The maps used for the analyses were the USGS 7.5 minute quadrangle maps for Mineral Point (1958) and Potosi (1958), Missouri.

b. Experience data. No recorded history of rainfall, runoff, discharge or pool elevation data were found for this reservoir and watershed.

c. Visual observation.

1. Watershed. The watershed is predominantly rural, consisting of forest, pasture, mined areas, and abandoned tailings ponds now densely overgrown by mature trees. Within the two tailings ponds upstream of the reservoir, mature vegetation has obliterated all traces of the original surface. No standing water was visible in the impoundment area of these tailings ponds at the time of our inspection. Even on the tailings embankments, plant growth has advanced to such a degree as to make passage difficult.

2. Reservoir. Floyd Lake is a small, shallow lake located near the downstream toe of two old tailings dams. The surface area of the lake is approximately 3 percent of the total drainage area of about 0.37 mi^2.

3. Spillway. The existing spillway is located at the northeast corner of the dam embankment (right abutment). The discharge channel follows the natural hillside for a short distance before sloping down towards the toe of the dam.

4. Seepage. The magnitude of seepage through Floyd Lake Dam is not hydrologically significant to the overtopping potential.

d. **Overtopping potential.** A primary consideration in the evaluation of Floyd Lake Dam is the assessment of the potential for overtopping and possible consequent failure by erosion of the embankment. The events considered are the 50 and 100 percent of Probable Maximum Flood (PMF) and the 1 and 10 percent probability-of-occurrence events. The PMF is defined as the flood event that may be expected to occur from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the area.

To account for the influence of the two old tailings ponds within the Floyd Lake watershed, two assumptions were made:

1. For the 1 and 10 percent probability-of-occurrence events, the two tailings ponds were assumed to hold the total runoff from their respective drainage areas (60 and 20 acres). Therefore, the effective contributing drainage area for Floyd Lake Dam was reduced by 80 acres.

2. For the 50 and 100 percent PMF events, the tailings ponds were assumed to be filled with runoff from the antecedent storm and were assumed to respond to the storms as impervious surfaces. These assumptions are based on the rather large pond surface to drainage area ratios of the two tailings impoundments.

The flow which can pass safely through the existing spillway without overtopping the main body of the dam embankment is on the order of 100 ft^3/sec, which is equivalent to the maximum outflow from a flood of about 5 percent of the PMF. It was also determined that the dam would be overtopped by the 10 percent probability-of-occurrence event. Overtopping of the dam would cause substantial risk of erosion both in the existing spillway area (particularly the low roadway fills composed of chat) and on the dam embankment. The indication of the comparatively large likelihood of overtopping is a consequence of the low capacity of the existing spillway and the small storage capacity of Floyd Lake Dam reservoir.

A more detailed hydrologic analysis of Floyd Lake Dam should be performed. This study should evaluate the options of increasing the capacity of the existing spillway and discharge channel, as well as re-opening of the apparently abandoned auxiliary spillway and discharge channel at the left abutment (west end) of the dam. The recommended hydrologic analysis should also include an evaluation of the potential for overtopping and subsequent failure of the abandoned tailings ponds upstream of Floyd Lake Dam.

For the existing conditions, the following data were computed for the various flood events:

Percent PMF	Maximum Reservoir Elevation, ft	Maximum Depth Over Dam, ft	Maximum Outflow, ft^3/sec	Duration of Overtopping, hrs
5	908.3	0.0	100	0.0
50	909.5	1.2	1700	6.8
100	909.9	1.6	3400	12.1

SECTION 6
STRUCTURAL STABILITY

6.1 Evaluation of Structural Stability

a. **Visual observations.** The visual inspection of Floyd Lake Dam indicates the dam is in generally poor condition. Also, because of the dense vegetation which obscured most of the dam, a judgment on the structural stability of the dam can only be made with comparatively limited observations and a low level of confidence.

There was no observed evidence of sinkholes or significant cracking of the dam or in the area beyond the toe of the dam. A narrow (1/8-in.) linear crack was noted extending 35 ft along the downstream edge of the dam crest. The crack was shallow (a few inches) and is probably due to minor non-uniform settling or shrinkage. The alignment of the dam crest can best be seen in Photo 5. The irregular alignment is probably not due to lateral shifting but rather due to the way the dam was originally constructed.

No animal burrows were seen on the dam but much of the downstream face was obscured by heavy vegetation. Adjacent grass fields did contain numerous small-diameter burrows.

Seepage and swampy ground was noted along much of the toe of the dam. At the confluence of the two small streamlets near the maximum section of the dam, the total flow at the time of our inspection amounted to approximately 5 gal/min. This included flow from a spring found at the eastern end of the dam. The seepage did not appear to be carrying any soil particles at the time of our inspection, but a more detailed check on the turbidity of the seepage should be undertaken after the dam face is made more visible.

The spillway is composed of silty, sandy gravel and is moderately erodible where it is not covered with grass. If the spillway was to erode moderately during a period of high flow, that action alone would apparently not jeopardize the dam due to the existing spillway location away from the main embankment.

The discharge channel is heavily obstructed with trees. In some places the channel has been eroded to bedrock. Further erosion can therefore only take place laterally and may endanger the toe of the dam, particularly if the discharge channel is further obstructed by any fallen trees.

b. **Design and construction data.** No design or construction records were available for this dam. All design and construction information was obtained from Mr Dall Groves and Mr Floyd. The information is presented in Sections 1.2.g. and 3.1.b. of this report.

Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available. This is a deficiency which should be corrected to meet the recommended guidelines.

c. **Operating records.** No operating records or water level records are maintained at this facility.

d. **Post construction changes.** Following construction of the earth dam in 1946, gravel-size tailings or chat were placed on the dam crest and dumped on the downstream face. This chat apparently forms only a thin veneer over the embankment.

The spillway at the west end of the dam has been filled-in to the elevation of the remainder of the dam crest (date unknown). Overflow is now restricted to the spillway at the east end of the embankment (right abutment).

The vegetation present on both the upstream and downstream faces has become established since mining operations were terminated in 1957. According to Mr Groves, the slopes were maintained clear of vegetation during the mining operations.

No other post-construction changes were identified during the visual inspection.

e. <u>**Seismic stability**</u>. The dam is in Seismic Zone 2 to which the guidelines assign a moderate damage potential. During a seismic event, liquefaction of the reportedly gravelly clay dam material is unlikely. However, without knowledge of the soil properties of the embankment materials, the seismic stability of the dam cannot be evaluated.

SECTION 7
ASSESSMENT/REMEDIAL MEASURES

7.1 Dam Assessment

a. **Safety.** Based on the visual inspection, the dam appears to be in a generally poor condition. Seriously inadequate spillway capacity, potential for erosion in the discharge channel at the toe of the dam, and the amount of vegetation on the embankment slopes are the main reasons for this judgement. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" are not on record, which is considered a deficiency.

The hydrologic analysis indicates that the dam will pass only five percent of the PMF without overtopping. Due to the proximity of the town of Old Mines (approximately 2 mi downstream), 100 percent of the PMF is recommended as an appropriate spillway design flood for this facility.

b. **Adequacy of information.** The visual inspection provided sufficient information to support the recommendations presented in this Phase I investigation. The lack of stability and seepage analyses, as recommended in the guidelines, precludes an evaluation of the static and seismic stability of the dam. This is a deficiency which should be corrected. These analyses should be conducted by an engineer experienced in the design and construction of earth dams.

c. **Urgency.** The deficiencies described in this report could affect the safety of the dam. The remedial measures concerning the spillway capacity, which should be analyzed and implemented immediately, are identified in Section 7.2b. The remaining recommendations should be addressed without undue delay.

d. **Necessity for Phase II.** In accordance with the "Recommended Guidelines for Safety Inspection of Dams", the subject investigation was a minimum study. This study revealed that additional in-depth investigations are needed to complete the assessment of the safety of the dam. Those investigations which should be performed immediately are described in Section 7.2b. It is our understanding from discussions with the SLD that any additional investigations are the responsibility of the owner.

7.2 Remedial Measures

a. **Alternatives.** There are several general options which may be considered to reduce the possibility of dam failure or to diminish the harmful consequences of such a failure. Some of these options are:

1. Remove the dam or breach it to prevent storage of water.

2. Increase the height of dam and/or spillway size to pass the Probable Maximum Flood without overtopping the dam.

3. Purchase downstream land that would be adversely impacted by dam failure and restrict human occupancy.

4. Provide a highly reliable flood warning system (generally does not prevent damage but decreases chances of loss of life).

b. **Recommendations.** Based on our inspection of Floyd Lake Dam, it is recommended that the following topic be evaluated immediately:

1. Prepare a more detailed hydrologic analysis, and design spillway and discharge channel systems capable of passing the PMF without overtopping the embankment. This could include repair of blocked spillway culverts and reopening the spillway at the west end of the dam.

Further recommendations which should be addressed without undue delay are the following:

2. Investigate the feasibility of the relocation of the downstream discharge channel away from the toe of the dam and/or provide an erosion control system for the spillway and downstream discharge channel.

3. Remove the trees and other detrimental vegetation from the dam embankment and the downstream discharge channel. Removal of large trees should only be done under the guidance of an engineer experienced in the design and construction of dams. Indiscriminate clearing could jeopardize the safety of the dam.

4. Perform seepage and stability analyses in accordance with the recommended guidelines.

All remedial measures should be evaluated and performed under the guidance of an engineer experienced in the design and construction of dams.

c. <u>O & M procedures.</u> As there are no operable facilities per se, it is recommended that a program of periodic inspections be developed and implemented. This inspection program should include but not be limited to:

1. Evaluation of erosion in the spillway and discharge channel;

2. Inspection of the embankment for signs of slope instability such as cracking or slumping;

3. Monitoring seepage to identify changes in seepage volume or turbidity (soil) in the seepage water.

The result of the inspection program should be to identify necessary maintenance, including maintaining discharge channels and the dam slopes free of trees and bushes. Records of the inspections and maintenance should be kept.

All inspections and maintenance should be performed under the guidance of an engineer experienced in the design and construction of earth dams.

REFERENCES

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Department of the Army, Office of the Chief of Engineers, 1977, EC 1110-2-188, "National Program of Inspection of Non-Federal Dams".

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Hydrologic Engineering Center, US Army Corps of Engineers, 1978, "Flood Hydrograph Package (HEC-1) Users Manual for Dam Safety Investigations".

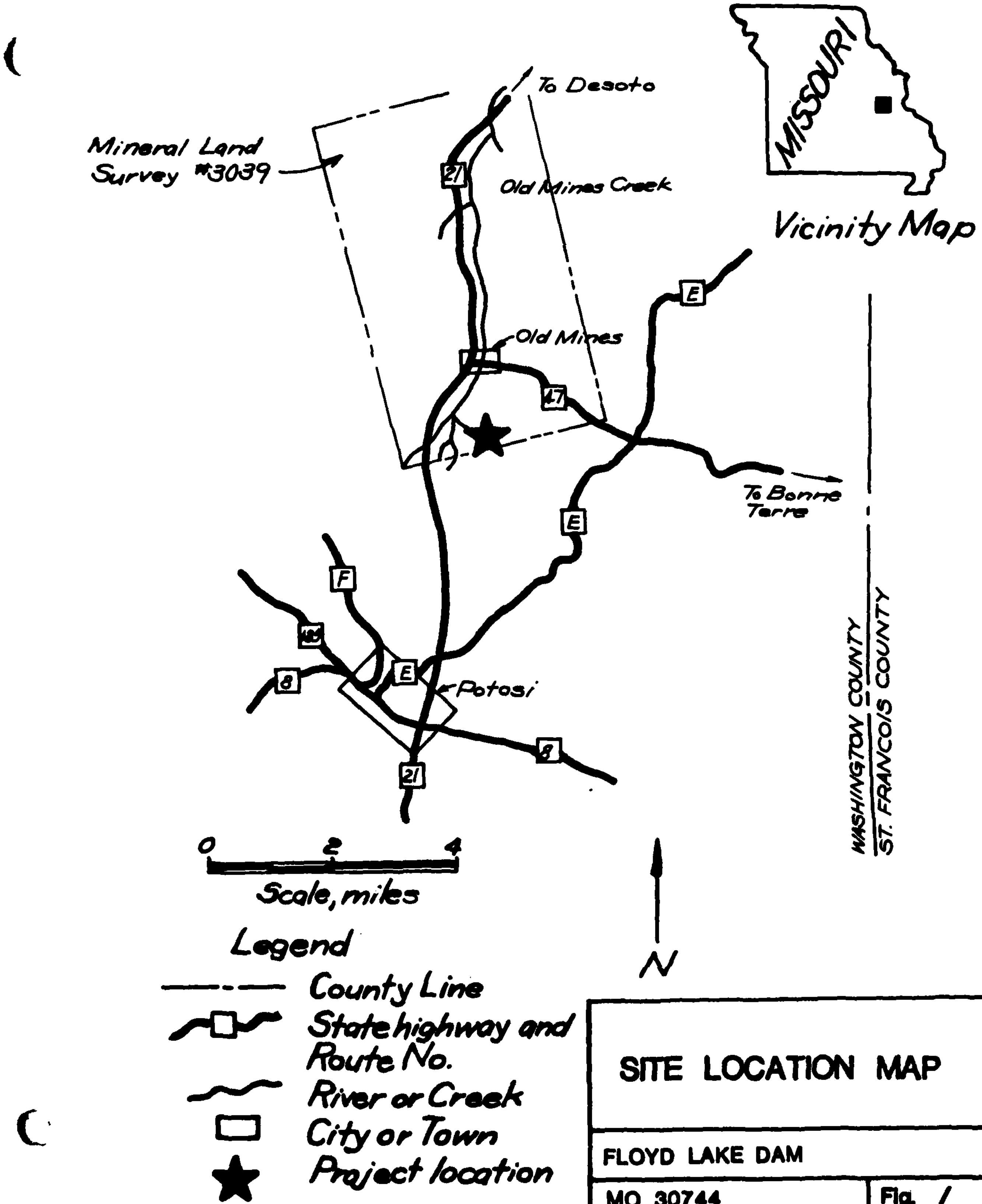
McCracken, Mary H., 1971, Structural Features Map of Missouri: Missouri Geological Survey, Scale 1:500,000.

Missouri Geological Survey, 1979, Geologic Map of Missouri: Missouri Geological Survey, Scale 1:500,000.

St Louis District, US Army Corps of Engineers, 1979, "Hydrologic/Hydraulic Standards, Phase I Safety Inspection of Non-Federal Dams".

US Department of Commerce, US Weather Bureau, 1956, "Seasonal Variation of the Probable Maximum Precipitation East of the 105th Meridian for Areas from 10 to 1,000 Square Miles and Durations of 6, 12, 24 and 48 Hours," Hydrometeorological Report No. 33.

US Soil Conservation Service, 1971, "National Engineering Handbook," Section 4, Hydrology, 1971.

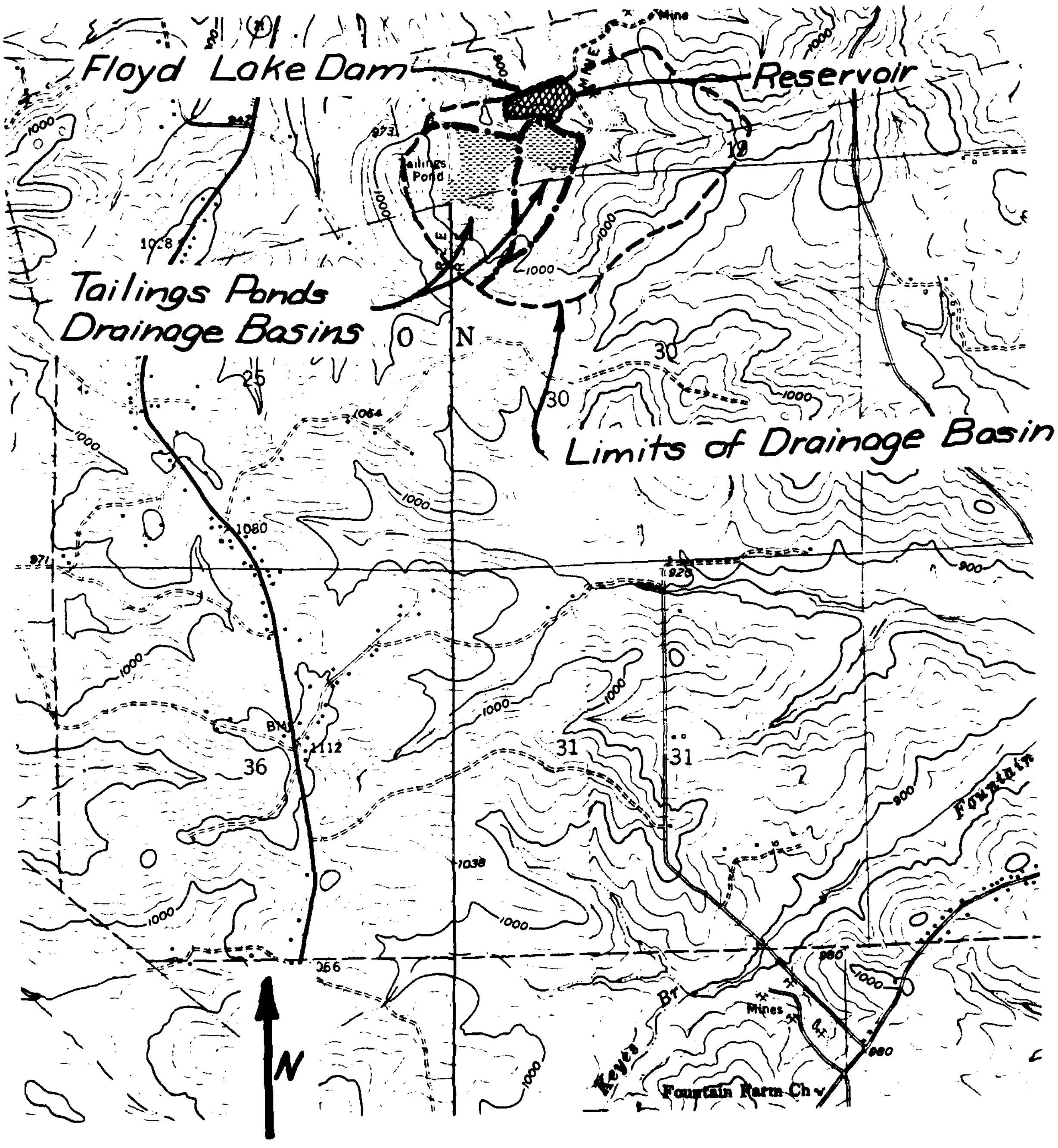


SITE LOCATION MAP

FLOYD LAKE DAM

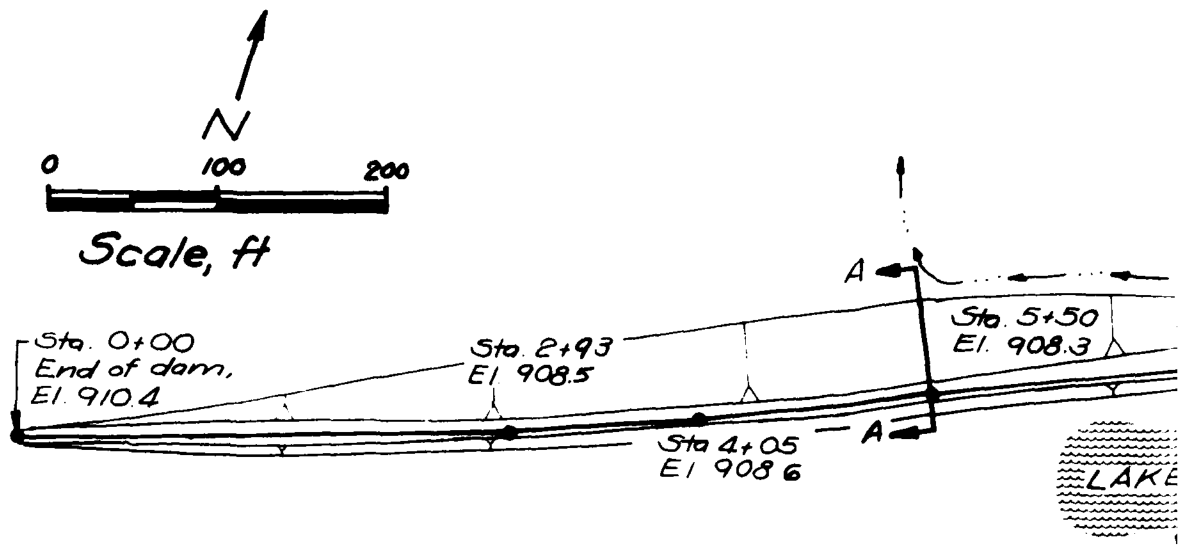
MO 30744

Fig. 1

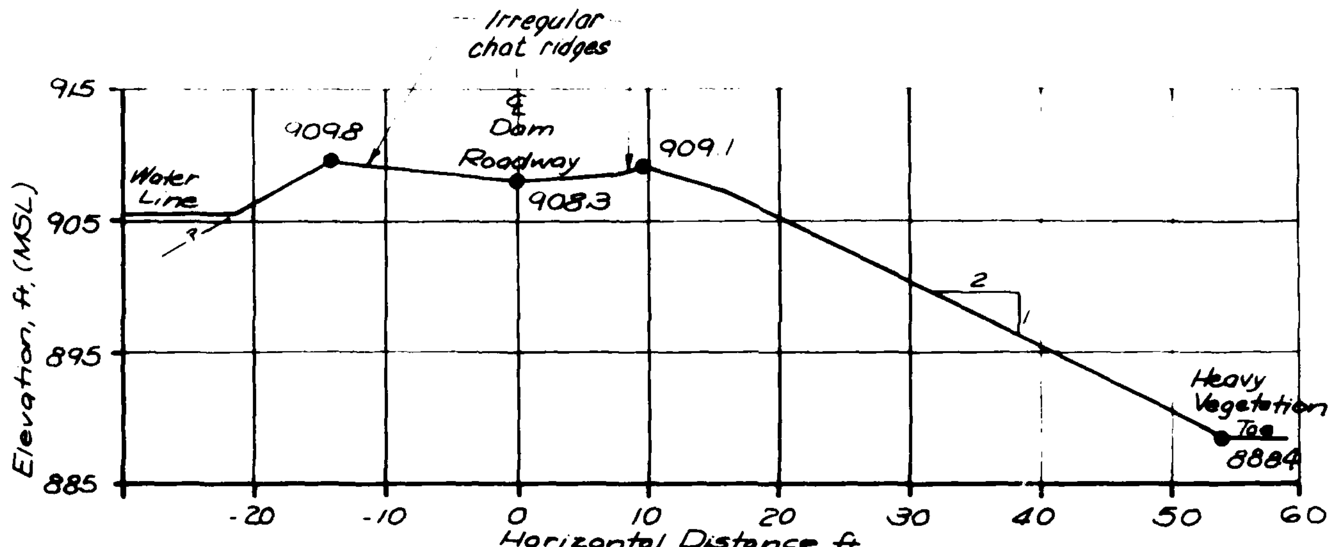


1. Topography from USGS Potosi and Mineral Point 7½ minute quadrangle maps.

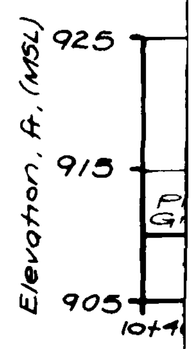
DRAINAGE BASIN AND SITE TOPOGRAPHY	
FLOYD LAKE DAM	
MO 30744	Fig. 2

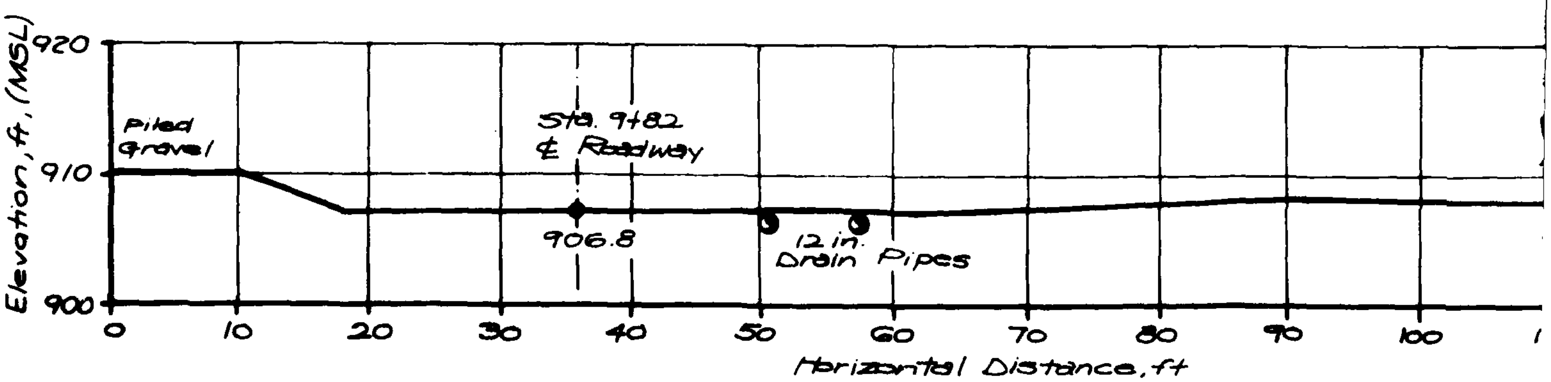


PLAN OF DA

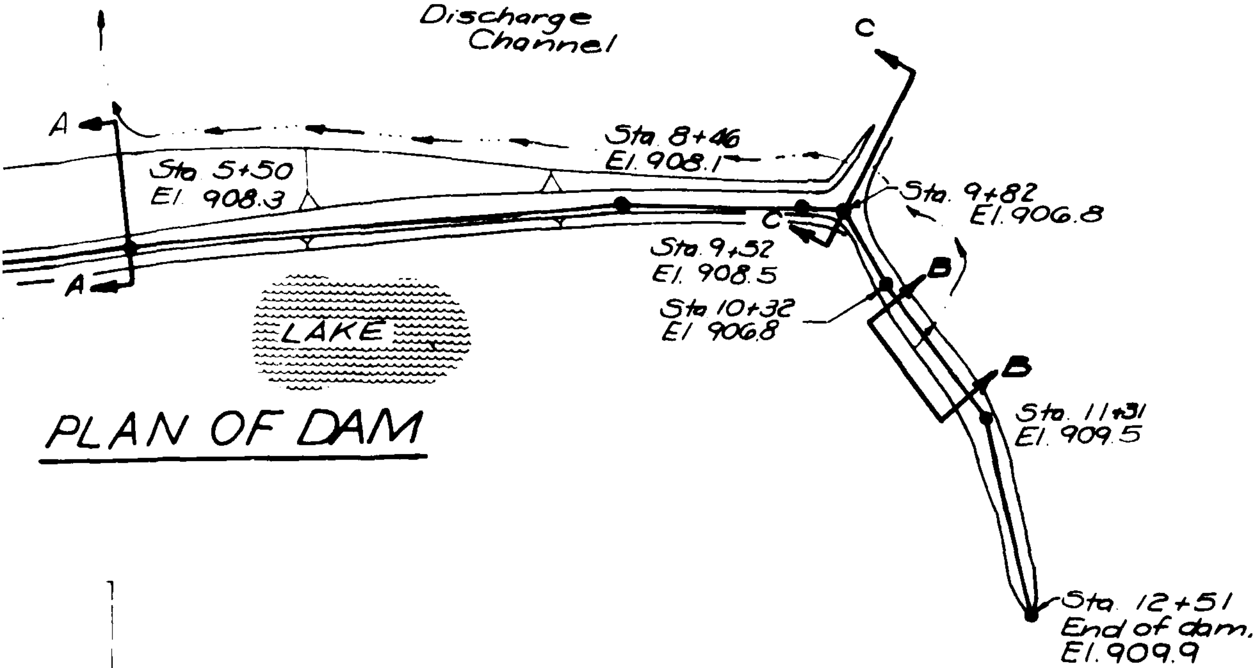


SECTION A-A
Maximum Section

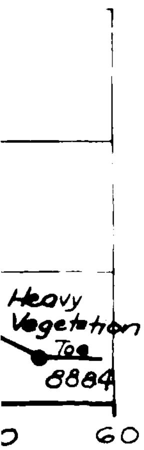


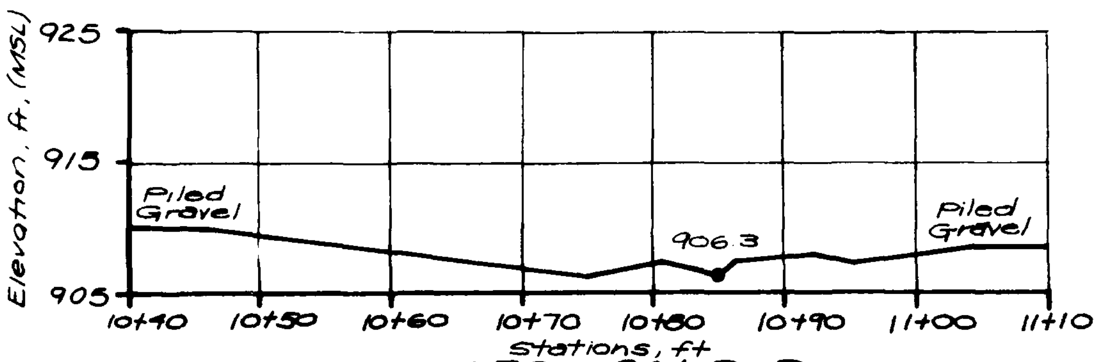


SECTION C-C
Discharge Channel



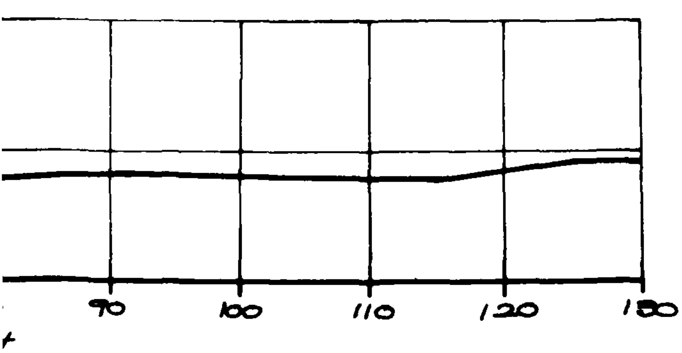
PLAN OF DAM





SECTION B-B

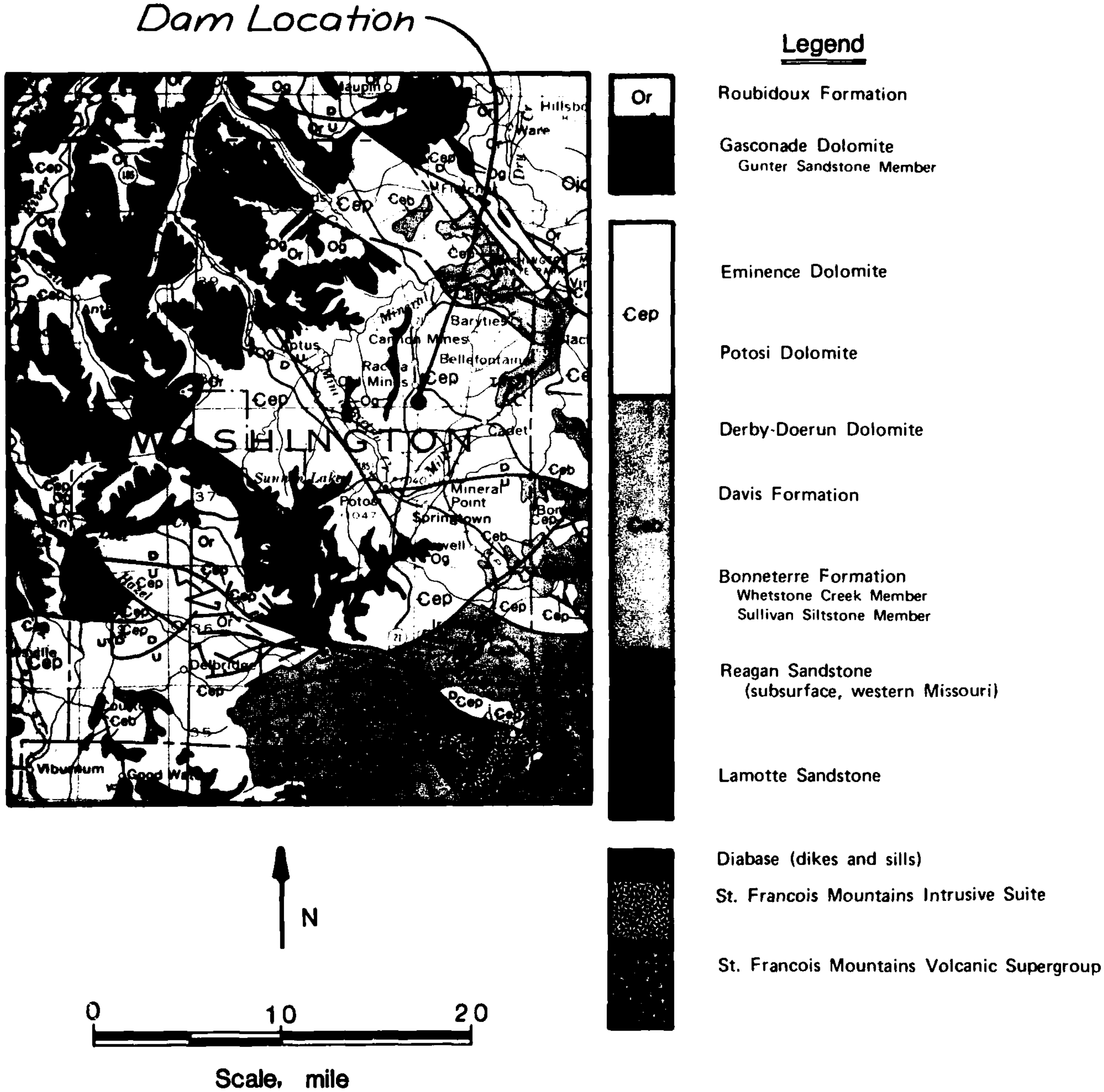
Spillway Section



2

PLAN AND SECTION OF DAM AND SECTION OF SPILLWAY AND DISCHARGE CHANNEL	
[illegible]	
MO. 30744	Fig. 3

Dam Location



REGIONAL GEOLOGIC MAP

FLOYD LAKE DAM	
MO 30744	Fig. 4

APPENDIX A

Photographs

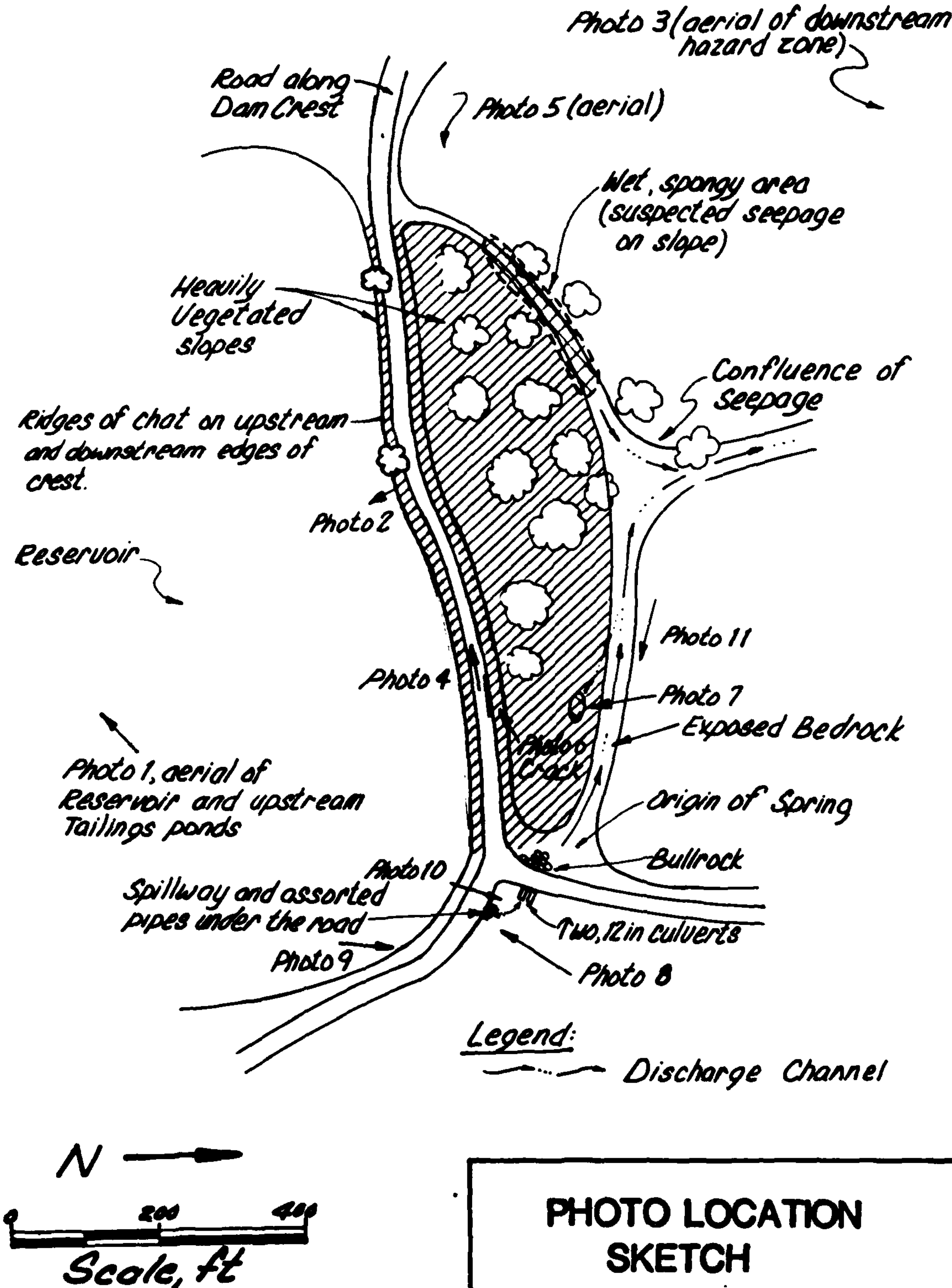


PHOTO LOCATION SKETCH	
FLOYD LAKE DAM	
MO 30744	Fig. A-1

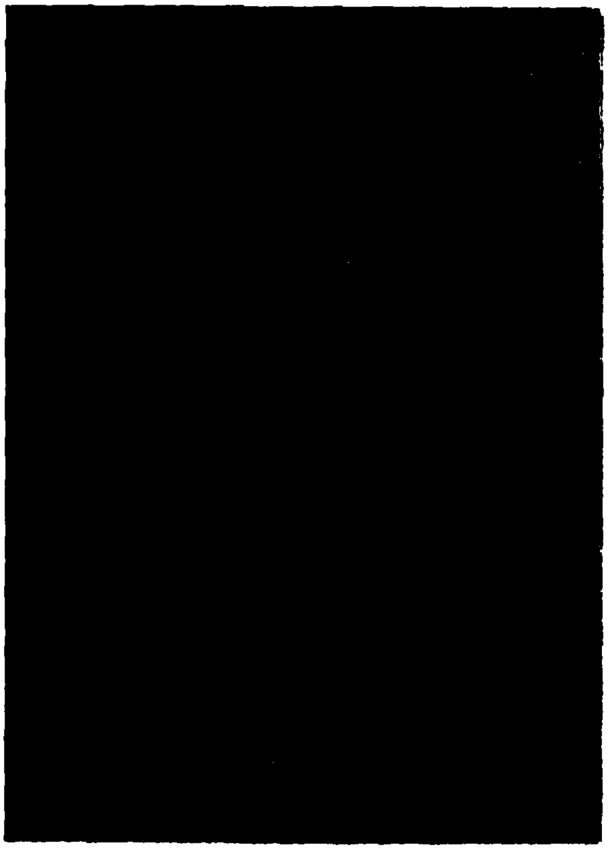
1. Aerial view of reservoir indicating the location of the two abandoned tailings ponds; looking southeast.

2. View of tailings pond dam upstream of reservoir; looking south.

3. Downstream hazards. Dam is out of picture to the right.

4. Road along the dam crest. Note the alignment of the road and low ridge of chat on the upstream face of the dam; looking west.

5. Aerial view of dam indicating crest alignment. Note the two abandoned tailings ponds on the right; looking east.



6. Small crack on downstream side of the roadway along the dam crest; looking east.

7. Seepage along the toe of the dam.

8. Reservoir level regulation culverts viewed at the discharge end; looking southwest.

9. Spillway with road crossing over the crest; looking northeast.

10. Entrance to two, 12 in. culverts; looking northeast.

11. View of downstream channel; looking upstream (east). Note the channel erosion to shallow bedrock and the type of vegetation.

APPENDIX B

Hydraulic/Hydrologic Data and Analyses

APPENDIX B
Hydraulic/Hydrologic Data and Analyses

B.1 Procedures

a. General. The hydraulic/hydrologic analyses were performed using the "HEC-1, Dam Safety Version (1 Apr 80)" computer program. The inflow hydrographs were developed for various precipitation events by applying them to a synthetic unit hydrograph. The inflow hydrographs were subsequently routed through the reservoir and appurtenant structures by the modified Puls reservoir routing option.

b. Precipitation events. The Probable Maximum Precipitation (PMP) and the 1 and 10 percent probability-of-occurrence events were used in the analyses. The total rainfall and corresponding distributions for the 1 and 10 percent probability events were provided by the St. Louis District, Corps of Engineers. The Probable Maximum Precipitation was determined from regional curves prepared by the US Weather Bureau (Hydrometeorological Report Number 33, 1956).

c. Unit hydrograph. The Soil Conservation Services (SCS) Dimensionless Unit Hydrograph method (National Engineering Handbook, Section 4, Hydrology, 1971) was used in the analysis. This method was selected because of its simplicity, applicability to drainage areas less than 10 mi^2, and its easy availability within the HEC-1 computer program.

The watershed lag time was computed using the SCS "curve number method" by an empirical relationship as follows:

$$L = \frac{\ell^{0.8}(s+1)^{0.7}}{1900\ Y^{0.5}} \qquad \text{(Equation 15-4)}$$

where: L = lag in hours
ℓ = hydraulic length of the watershed in feet
$s = \frac{1000}{CN} - 10$ where CN = hydrologic soil curve number
Y = average watershed land slope in percent

This empirical relationship accounts for the soil cover, average watershed slope and hydraulic length.

With the lag time thus computed, another empirical relationship is used to compute the time of concentration as follows:

$$T_c = \frac{L}{0.6} \qquad \text{(Equation 15-3)}$$

where: T_c = time of concentration in hours

L = lag in hours.

Subsequent to the computation of the time of concentration, the unit hydrograph duration was estimated utilizing the following relationship:

$$\Delta D = 0.133T_c \qquad \text{(Equation 16-12)}$$

where: ΔD = duration of unit excess rainfall
T_c = time of concentration in hours.

The final interval was selected to provide at least three discharge ordinates prior to the peak discharge ordinate of the unit hydrograph. For this dam, a time interval of 5 minutes was used.

d. Infiltration losses. The infiltration losses were computed by the HEC-1 computer program internally using the SCS curve number method. The curve numbers were established taking into consideration the variables of: (a) antecedent moisture condition, (b) hydrologic soil group classification, (c) degree of development, (d) vegetative cover and (e) present land usage in the watershed.

Antecedent moisture condition III (AMC III) was used for the PMF events and AMC II was used for the 1 and 10 percent probability events, in accordance with the guidelines. The remaining variables are defined in the SCS procedure and judgements in their selection were made on the basis of visual field inspection.

e. Starting elevations. Reservoir starting water surface elevations for this dam were set as follows:

(1) 1 and 10 percent probability events - spillway crest elevation

(2) Probable Maximum Storm - spillway crest elevation

Because the low level outlet pipes are of small diameter, it was assumed they were either blocked or inoperable and did not pass any amount of the flood.

f. Spillway Rating Curve. The HEC-2 computer program was used to compute the spillway rating curve using discharge channel cross sections and conveyance characteristics.

B.2 Pertinent Data

a. Drainage area. 0.39 mi^2 for PMF events (0.26 mi^2 for 1 and 10 percent probability-of-occurrence events; see Section 5).

b. Storm duration. A unit hydrograph was developed by the SCS method option of HEC-1 program. The design storm of 24 hours duration was divided into 5 minute intervals in order to develop the inflow hydrograph.

c. Lag time. 0.37 hrs

d. Hydrologic soil group. C

e. SCS curve numbers.

1. For PMF- AMC III - Curve Number 89
2. For 1 and 10 percent probability-of-occurrence events AMC II - Curve Number 76

f. Storage. Elevation-area data were developed by planimetering areas at various elevation contours on the USGS Potosi 7.5 minute quadrangle map. The data were entered on the $A and $E cards so that the HEC-1 program could compute storage volumes.

g. Outflow over dam crest. As the profile of the dam crest is irregular, flow over the crest was computed according to the "Flow Over Non-Level Dam Crest" supplement to the HEC-1 User's Manual. The crest length-elevation data and hydraulic constants were entered on the $D, $L, and $V cards.

h. Outflow capacity. The spillway rating curve was developed from the cross-section data of the spillway and the downstream channel, using the HEC-2 back water program. The results of the above were entered on the Y-4 and Y-5 cards of the HEC-1 program.

i. Reservoir elevations. For the 50 and 100 percent of the PMF events, the starting reservoir elevation was 906.3 ft, the spillway crest elevation. For the 1 and 10 percent probability-of-occurrence events, the starting reservoir elevation was 906.3 ft, the spillway crest elevation.

B.3 Results

The results of the analyses as well as the input values to the HEC-1 program follow in this Appendix. Only the results summaries are included, not the intermediate output. Complete copies of the HEC-1 output are available in the project files.

```
************************************
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION        JULY 1978
  LAST MODIFICATION  01 APR 80
************************************
A1      DAM NO. 30744 - FLOYD LAKE, WASHINGTON COUNTY, MISSOURI.
A2      WOODWARD-CLYDE CONSULTANTS, HOUSTON JOB 79CH009.
A3     PMF ANALYSIS, TAILINGS PONDS ASSUMED ALREADY FULL-THEN ASSUME IMPERVIOUS.
B    288       0       5      -0      -0      -0      -0      -0      -0      -0
B1     5
J      1       4       1
J1   .25     .50     .75    1.00
K      0    0-IN                                      1
K1  FLOYD LAKE DAM INFLOW COMPUTATION, PMF RATIO FLOODS.
M      1       2    0.39                     1.0
P      0     26.     102     120     130
T                                                    -1     -89             0.125
W2          0.37
X     -1    -.05       5
K      1     DAM                                      1
K1  FLOYD LAKE DAM PMF FLOOD ROUTINGS.
Y                              1       1
Y1     1                                         -906.3      -1
Y4 906.3   907.4   907.6   907.9   908.3   908.8   909.5   910.1   911.4   912.4
Y5    0.     10.     20.     50.    100.    200.    500.   1000.   3000.   5000.
SA    0.      6.     7.5      8.     8.3
SE  888.   906.3   908.3    910.    912.
SS 986.3
SD 908.3     2.8     1.5
SL    0.    165.    475.    650.    815.    950.
SV 908.3   908.5    909.   909.5    910.   910.5
K     99
```

Input Data
Various PMF Events
Floyd Lake Dam
MO ID 30744
B4

Input Data
Various PMF Events
Floyd Lake Dam
MO ID 30744
B5

```
**********************************
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION       JULY 1978
  LAST MODIFICATION  01 APR 80
**********************************

RUN  DATE: 21 AUG 80
     TIME: 14.27.58

        DAM NO. 30744 - FLOYD LAKE, WASHINGTON COUNTY, MISSOURI.
         WOODWARD-CLYDE CONSULTANTS, HOUSTON JOB 79CH009.
        PMF ANALYSIS, TAILINGS PONDS ASSUMED ALREADY FULL-THEN ASSUME IMPERVIOUS.

                           JOB SPECIFICATION
    NQ    NHR   NMIN   IDAY    IHR   IMIN  METRC   IPLT   IPRT  NSTAN
   288      0      5     -0     -0     -0     -0     -0     -0     -0
                      JOPER    NWT  LROPT  TRACE
                          5     -0     -0     -0

                 MULTI-PLAN ANALYSES TO BE PERFORMED
                      NPLAN= 1 NRTIO= 4 LRTIO= 1
    RTIOS=    .25    .50    .75   1.00

   *********        *********        *********        *********        *********

                       SUB-AREA RUNOFF COMPUTATION

   FLOYD LAKE DAM INFLOW COMPUTATION, PMF RATIO FLOODS.

          ISTAQ  ICOMP  IECON  ITAPE   JPLT   JPRT  INAME ISTAGE  IAUTO
           0-IN      0     -0     -0     -0     -0      1     -0     -0

                            HYDROGRAPH DATA
   IHYDG  IUHG  TAREA   SNAP  TRSDA  TRSPC  RATIO  ISNOW  ISAME  LOCAL
       1     2    .39    -0.    .39   1.00    -0.     -0     -0     -0

                              PRECIP DATA
          SPFE    PMS     R6    R12    R24    R48    R72    R96
            0.  26.00 102.00 120.00 130.00    -0.    -0.    -0.

                               LOSS DATA
   LROPT  STRKR  DLTKR  RTIOL  ERAIN  STRKS  RTIOK  STRTL  CNSTL  ALSMX  RTIMP
      -0     -0.    -0.   1.00    -0.    -0.   1.00  -1.00 -99.00    -0.    .13
```

PRECIP DATA

SPFE	PMS	R6	R12	R24	R48	R72	R96
0.	26.00	102.00	120.00	130.00	-0.	-0.	-0.

LOSS DATA

LROPT	STRKR	DLTKR	RTIOL	ERAIN	STRKS	RTIOK	STRTL	CNSTL	ALSMX	RTIMP
0	-0.	-0.	1.00	-0.	-0.	1.00	-1.00	-89.00	-0.	.13

CURVE NO = -89.00 WETNESS = -1.00 EFFECT CN = 89.00

UNIT HYDROGRAPH DATA
TC= -0. LAG= .37

RECESSION DATA
STRTQ= -1.00 QRCSN= -.05 RTIOR= 5.00

UNIT HYDROGRAPH 24 END OF PERIOD ORDINATES, TC= -0. HOURS, LAG= .37 VOL= 1.00

47.	145.	308.	428.	457.	421.	349.	247.	173.	124.
91.	65.	47.	34.	24.	17.	13.	9.	6.	5.
4.	3.	2.	1.						

END-OF-PERIOD FLOW

MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q	MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q
1.01	.05	1	.01	.00	.01	0.	1.01	12.05	145	.22	.21	.01	197.
1.01	.10	2	.01	.00	.01	1.	1.01	12.10	146	.22	.22	.01	219.
1.01	.15	3	.01	.00	.01	1.	1.01	12.15	147	.22	.22	.01	266.
1.01	.20	4	.01	.00	.01	2.	1.01	12.20	148	.22	.22	.01	331.
1.01	.25	5	.01	.00	.01	3.	1.01	12.25	149	.22	.22	.00	401.
1.01	.30	6	.01	.00	.01	3.	1.01	12.30	150	.22	.22	.00	465.
1.01	.35	7	.01	.00	.01	4.	1.01	12.35	151	.22	.22	.00	519.
1.01	.40	8	.01	.00	.01	4.	1.01	12.40	152	.22	.22	.00	557.
1.01	.45	9	.01	.00	.01	5.	1.01	12.45	153	.22	.22	.00	584.
1.01	.50	10	.01	.00	.01	5.	1.01	12.50	154	.22	.22	.00	604.
1.01	.55	11	.01	.00	.01	5.	1.01	12.55	155	.22	.22	.00	618.
1.01	1.00	12	.01	.00	.01	5.	1.01	13.00	156	.22	.22	.00	629.
1.01	1.05	13	.01	.00	.01	5.	1.01	13.05	157	.27	.26	.00	638.
1.01	1.10	14	.01	.00	.01	5.	1.01	13.10	158	.27	.26	.00	650.
1.01	1.15	15	.01	.00	.01	5.	1.01	13.15	159	.27	.26	.00	668.
1.01	1.20	16	.01	.00	.01	5.	1.01	13.20	160	.27	.26	.00	690.
1.01	1.25	17	.01	.00	.01	5.	1.01	13.25	161	.27	.26	.00	712.
1.01	1.30	18	.01	.00	.01	5.	1.01	13.30	162	.27	.26	.00	733.
1.01	1.35	19	.01	.00	.01	5.	1.01	13.35	163	.27	.26	.00	749.
1.01	1.40	20	.01	.00	.01	6.	1.01	13.40	164	.27	.26	.00	761.
1.01	1.45	21	.01	.00	.01	6.	1.01	13.45	165	.27	.26	.00	770.
1.01	1.50	22	.01	.00	.01	6.	1.01	13.50	166	.27	.26	.00	776.
1.01	1.55	23	.01	.00	.01	7.	1.01	13.55	167	.27	.26	.00	781.
1.01	2.00	24	.01	.00	.01	7.	1.01	14.00	168	.27	.26	.00	784.
1.01	2.05	25	.01	.00	.01	8.	1.01	14.05	169	.33	.33	.00	790.
1.01	2.10	26	.01	.00	.01	8.	1.01	14.10	170	.33	.33	.00	801.
1.01	2.15	27	.01	.00	.01	9.	1.01	14.15	171	.33	.33	.00	823.
1.01	2.20	28	.01	.00	.01	10.	1.01	14.20	172	.33	.33	.00	852.
1.01	2.25	29	.01	.00	.01	10.	1.01	14.25	173	.33	.33	.00	883.
1.01	2.30	30	.01	.00	.01	11.	1.01	14.30	174	.33	.33	.00	912.
1.01	2.35	31	.01	.00	.01	12.	1.01	14.35	175	.33	.33	.00	935.
1.01	2.40	32	.01	.01	.01	12.	1.01	14.40	176	.33	.33	.00	952.
1.01	2.45	33	.01	.01	.01	13.	1.01	14.45	177	.33	.33	.00	964.
1.01	2.50	34	.01	.01	.01	14.	1.01	14.50	178	.33	.33	.00	973.
1.01	2.55	35	.01	.01	.01	14.	1.01	14.55	179	.33	.33	.00	979.
1.01	3.00	36	.01	.01	.01	15.	1.01	15.00	180	.33	.33	.00	984.
1.01	3.05	37	.01	.01	.01	15.	1.01	15.05	181	[illegible]	[illegible]	.00	[illegible]

Input Data
Various PMF Events
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[illegible]	[illegible]	34	.01	.01	.01	14.	1.01	14.50	178	.33	.33	.00	973.
1.01	2.55	35	.01	.01	.01	14.	1.01	14.55	179	.33	.33	.00	979.
1.01	3.00	36	.01	.01	.01	15.	1.01	15.00	180	.33	.33	.00	984.
1.01	3.05	37	.01	.01	.01	15.	1.01	15.05	181	.20	.20	.00	981.
1.01	3.10	38	.01	.01	.01	16.	1.01	15.10	182	.40	.40	.00	974.
1.01	3.15	39	.01	.01	.01	16.	1.01	15.15	183	.40	.40	.00	985.
1.01	3.20	40	.01	.01	.01	17.	1.01	15.20	184	.60	.60	.00	982.
1.01	3.25	41	.01	.01	.01	17.	1.01	15.25	185	.71	.70	.00	1044.
1.01	3.30	42	.01	.01	.01	18.	1.01	15.30	186	1.71	1.71	.01	1209.
1.01	3.35	43	.01	.01	.01	18.	1.01	15.35	187	2.82	2.81	.01	1560.
1.01	3.40	44	.01	.01	.01	19.	1.01	15.40	188	1.11	1.11	.00	2124.
1.01	3.45	45	.01	.01	.01	19.	1.01	15.45	189	.71	.70	.00	2785.
1.01	3.50	46	.01	.01	.01	20.	1.01	15.50	190	.60	.60	.00	3282.
1.01	3.55	47	.01	.01	.01	20.	1.01	15.55	191	.40	.40	.00	3409.
1.01	4.00	48	.01	.01	.01	21.	1.01	16.00	192	.40	.40	.00	3282.
1.01	4.05	49	.01	.01	.01	21.	1.01	16.05	193	.31	.31	.00	2954.
1.01	4.10	50	.01	.01	.01	21.	1.01	16.10	194	.31	.31	.00	2926.
1.01	4.15	51	.01	.01	.01	22.	1.01	16.15	195	.31	.31	.00	2141.
1.01	4.20	52	.01	.01	.01	22.	1.01	16.20	196	.31	.31	.00	1834.
1.01	4.25	53	.01	.01	.01	23.	1.01	16.25	197	.31	.31	.00	1554.
1.01	4.30	54	.01	.01	.01	23.	1.01	16.30	198	.31	.31	.00	1410.
1.01	4.35	55	.01	.01	.01	23.	1.01	16.35	199	.31	.31	.00	1276.
1.01	4.40	56	.01	.01	.01	24.	1.01	16.40	200	.31	.31	.00	1179.
1.01	4.45	57	.01	.01	.01	24.	1.01	16.45	201	.31	.31	.00	1109.
1.01	4.50	58	.01	.01	.01	24.	1.01	16.50	202	.31	.31	.00	1060.
1.01	4.55	59	.01	.01	.01	25.	1.01	16.55	203	.31	.31	.00	1024.
1.01	5.00	60	.01	.01	.01	25.	1.01	17.00	204	.31	.31	.00	999.
1.01	5.05	61	.01	.01	.01	25.	1.01	17.05	205	.24	.24	.00	977.
1.01	5.10	62	.01	.01	.01	26.	1.01	17.10	206	.24	.24	.00	995.
1.01	5.15	63	.01	.01	.01	26.	1.01	17.15	207	.24	.24	.00	929.
1.01	5.20	64	.01	.01	.01	26.	1.01	17.20	208	.24	.24	.00	889.
1.01	5.25	65	.01	.01	.01	26.	1.01	17.25	209	.24	.24	.00	852.
1.01	5.30	66	.01	.01	.01	27.	1.01	17.30	210	.24	.24	.00	819.
1.01	5.35	67	.01	.01	.01	27.	1.01	17.35	211	.24	.24	.00	793.
1.01	5.40	68	.01	.01	.01	27.	1.01	17.40	212	.24	.24	.00	775.
1.01	5.45	69	.01	.01	.00	27.	1.01	17.45	213	.24	.24	.00	763.
1.01	5.50	70	.01	.01	.00	28.	1.01	17.50	214	.24	.24	.00	754.
1.01	5.55	71	.01	.01	.00	28.	1.01	17.55	215	.24	.24	.00	748.
1.01	6.00	72	.01	.01	.00	28.	1.01	18.00	216	.24	.24	.00	744.
1.01	6.05	73	.07	.04	.02	30.	1.01	18.05	217	.02	.02	.00	730.
1.01	6.10	74	.07	.05	.02	35.	1.01	18.10	218	.02	.02	.00	656.
1.01	6.15	75	.07	.05	.02	46.	1.01	18.15	219	.02	.02	.00	626.
1.01	6.20	76	.07	.05	.02	62.	1.01	18.20	220	.02	.02	.00	530.
1.01	6.25	77	.07	.05	.02	79.	1.01	18.25	221	.02	.02	.00	428.
1.01	6.30	78	.07	.05	.02	96.	1.01	18.30	222	.02	.02	.00	335.
1.01	6.35	79	.07	.05	.01	110.	1.01	18.35	223	.02	.02	.00	297.
1.01	6.40	80	.07	.05	.01	121.	1.01	18.40	224	.02	.02	.00	202.
1.01	6.45	81	.07	.05	.01	129.	1.01	18.45	225	.02	.02	.00	166.
1.01	6.50	82	.07	.05	.01	136.	1.01	18.50	226	.02	.02	.00	141.
1.01	6.55	83	.07	.05	.01	141.	1.01	18.55	227	.02	.02	.00	120.
1.01	7.00	84	.07	.05	.01	146.	1.01	19.00	228	.02	.02	.00	102.
1.01	7.05	85	.07	.05	.01	149.	1.01	19.05	229	.02	.02	.00	91.
1.01	7.10	86	.07	.05	.01	153.	1.01	19.10	230	.02	.02	.00	84.
1.01	7.15	87	.07	.06	.01	155.	1.01	19.15	231	.02	.02	.00	78.
1.01	7.20	88	.07	.06	.01	158.	1.01	19.20	232	.02	.02	.00	74.
1.01	7.25	89	.07	.06	.01	160.	1.01	19.25	233	.02	.02	.00	72.
1.01	7.30	90	.07	.06	.01	162.	1.01	19.30	234	.02	.02	.00	70.
1.01	7.35	91	.07	.06	.01	164.	1.01	19.35	235	.02	.02	.00	68.
1.01	7.40	92	.07	.06	.01	165.	1.01	19.40	236	.02	.02	.00	67.
1.01	7.45	93	.07	.06	.01	167.	1.01	19.45	237	.02	.02	.00	66.
1.01	7.50	94	.07	.06	.01	168.	1.01	19.50	238	.02	.02	.00	66.
1.01	7.55	95	.07	.06	.01	169.	1.01	19.55	239	.02	.02	.00	65.
1.01	8.00	96	.07	.06	.01	170.	1.01	20.00	240	.02	.02	.00	65.
1.01	8.05	97	.07	.05	.01	171.	1.01	20.05	241	.02	.02	.00	64.
1.01	8.10												

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1.01	7.45	93	.07	.06	.01	167.	1.01	19.45	237	.02	.02	.00	66.
1.01	7.50	94	.07	.06	.01	168.	1.01	19.50	238	.02	.02	.00	66.
1.01	7.55	95	.07	.06	.01	169.	1.01	19.55	239	.02	.02	.00	65.
1.01	8.00	96	.07	.06	.01	170.	1.01	20.00	240	.02	.02	.00	65.
1.01	8.05	97	.07	.05	.01	171.	1.01	20.05	241	.02	.02	.00	65.
1.01	8.10	98	.07	.06	.01	172.	1.01	20.10	242	.02	.02	.00	65.
1.01	8.15	99	.07	.06	.01	173.	1.01	20.15	243	.02	.02	.00	65.
1.01	8.20	100	.07	.06	.01	174.	1.01	20.20	244	.02	.02	.00	65.
1.01	8.25	101	.07	.06	.01	175.	1.01	20.25	245	.02	.02	.00	65.
1.01	8.30	102	.07	.06	.01	176.	1.01	20.30	246	.02	.02	.00	65.
1.01	8.35	103	.07	.06	.01	176.	1.01	20.35	247	.02	.02	.00	65.
1.01	8.40	104	.07	.06	.01	177.	1.01	20.40	248	.02	.02	.00	65.
1.01	8.45	105	.07	.06	.01	178.	1.01	20.45	249	.02	.02	.00	65.
1.01	8.50	106	.07	.06	.00	179.	1.01	20.50	250	.02	.02	.00	65.
1.01	8.55	107	.07	.06	.00	179.	1.01	20.55	251	.02	.02	.00	65.
1.01	9.00	108	.07	.06	.00	180.	1.01	21.00	252	.02	.02	.00	65.
1.01	9.05	109	.07	.06	.00	180.	1.01	21.05	253	.02	.02	.00	65.
1.01	9.10	110	.07	.06	.00	181.	1.01	21.10	254	.02	.02	.00	65.
1.01	9.15	111	.07	.06	.00	181.	1.01	21.15	255	.02	.02	.00	65.
1.01	9.20	112	.07	.06	.00	182.	1.01	21.20	256	.02	.02	.00	65.
1.01	9.25	113	.07	.06	.00	182.	1.01	21.25	257	.02	.02	.00	65.
1.01	9.30	114	.07	.06	.00	182.	1.01	21.30	258	.02	.02	.00	65.
1.01	9.35	115	.07	.06	.00	183.	1.01	21.35	259	.02	.02	.00	65.
1.01	9.40	116	.07	.06	.00	183.	1.01	21.40	260	.02	.02	.00	65.
1.01	9.45	117	.07	.06	.00	184.	1.01	21.45	261	.02	.02	.00	65.
1.01	9.50	118	.07	.05	.00	184.	1.01	21.50	262	.02	.02	.00	65.
1.01	9.55	119	.07	.06	.00	184.	1.01	21.55	263	.02	.02	.00	65.
1.01	10.00	120	.07	.06	.00	185.	1.01	22.00	264	.02	.02	.00	65.
1.01	10.05	121	.07	.06	.00	185.	1.01	22.05	265	.02	.02	.00	65.
1.01	10.10	122	.07	.06	.00	185.	1.01	22.10	266	.02	.02	.00	65.
1.01	10.15	123	.07	.06	.00	185.	1.01	22.15	267	.02	.02	.00	65.
1.01	10.20	124	.07	.06	.00	186.	1.01	22.20	268	.02	.02	.00	65.
1.01	10.25	125	.07	.06	.00	186.	1.01	22.25	269	.02	.02	.00	65.
1.01	10.30	126	.07	.06	.00	186.	1.01	22.30	270	.02	.02	.00	65.
1.01	10.35	127	.07	.06	.00	187.	1.01	22.35	271	.02	.02	.00	65.
1.01	10.40	128	.07	.06	.00	187.	1.01	22.40	272	.02	.02	.00	65.
1.01	10.45	129	.07	.06	.00	187.	1.01	22.45	273	.02	.02	.00	65.
1.01	10.50	130	.07	.06	.00	187.	1.01	22.50	274	.02	.02	.00	65.
1.01	10.55	131	.07	.06	.00	187.	1.01	22.55	275	.02	.02	.00	65.
1.01	11.00	132	.07	.06	.00	188.	1.01	23.00	276	.02	.02	.00	65.
1.01	11.05	133	.07	.06	.00	188.	1.01	23.05	277	.02	.02	.00	65.
1.01	11.10	134	.07	.06	.00	188.	1.01	23.10	278	.02	.02	.00	65.
1.01	11.15	135	.07	.06	.00	188.	1.01	23.15	279	.02	.02	.00	65.
1.01	11.20	136	.07	.06	.00	188.	1.01	23.20	280	.02	.02	.00	65.
1.01	11.25	137	.07	.06	.00	189.	1.01	23.25	281	.02	.02	.00	65.
1.01	11.30	138	.07	.06	.00	189.	1.01	23.30	282	.02	.02	.00	65.
1.01	11.35	139	.07	.06	.00	189.	1.01	23.35	283	.02	.02	.00	65.
1.01	11.40	140	.07	.06	.00	189.	1.01	23.40	284	.02	.02	.00	65.
1.01	11.45	141	.07	.06	.00	189.	1.01	23.45	285	.02	.02	.00	65.
1.01	11.50	142	.07	.06	.00	189.	1.01	23.50	286	.02	.02	.00	65.
1.01	11.55	143	.07	.06	.00	189.	1.01	23.55	287	.02	.02	.00	65.
1.01	12.00	144	.07	.06	.00	190.	1.02	0.	288	.02	.02	.00	65.
									SUM	33.80	32.54	1.26	97869.
										(859.)(	827.)(	32.)(	2771.34)

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	3409.	1086.	340.	340.	97858.
CMS	97.	31.	10.	10.	2771.
INCHES		25.41	32.42	32.42	32.42
MM		658.08	823.43	823.43	823.43
AC-FT		539.	674.	674.	674.
THOUS CU M		664.	831.	831.	831.

Input Data
Various PMF Events
Floyd Lake Dam
MO ID 30744
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PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
AREA IN SQUARE MILES (SQUARE KILOMETERS)

OPERATION	STATION	AREA	PLAN	RATIOS APPLIED TO FLOWS RATIO 1 .25	RATIO 2 .50	RATIO 3 .75	RATIO 4 1.00
HYDROGRAPH AT	O-IN	.39	1	852.	1705.	2557.	3409.
	(	1.01)	(	24.13)(	48.27)(	72.40)(	96.54)(
ROUTED TO	DAM	.39	1	835.	1679.	2538.	3391.
	(	1.01)	(	23.65)(	47.55)(	71.86)(	96.03)(

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 ....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	906.30	906.30	908.30
STORAGE	37.	37.	50.
OUTFLOW	0.	0.	100.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.25	909.10	.80	56.	835.	5.75	16.00	0.
.50	909.46	1.16	59.	1679.	6.75	15.92	0.
.75	909.72	1.42	61.	2538.	11.17	15.92	0.
1.00	909.93	1.63	63.	3391.	12.08	15.92	0.

Output Summary
Various PMF Events
Floyd Lake Dam
MO ID 30744
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PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
AREA IN SQUARE MILES (SQUARE KILOMETERS)

OPERATION	STATION	AREA	PLAN	RATIO 1 .05	RATIO 2 .06	RATIO 3 .07
				RATIOS APPLIED TO FLOWS		
HYDROGRAPH AT	Q-IN	.39	1	170.	205.	239.
	(	1.01)	(	4.53)(	5.79)(	6.76)(
ROUTED TO	DAM	.39	1	100.	137.	180.
	(	1.01)	(	2.84)(	3.88)(	5.10)(

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 ....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	906.30	906.30	908.30
STORAGE	37.	37.	50.
OUTFLOW	0.	0.	100.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.05	908.30	.00	50.	100.	.17	16.25	0.
.06	908.45	.19	51.	137.	.79	16.25	0.
.07	908.55	.25	52.	180.	1.00	16.17	0.

Output Summary
Various PMF Events
Floyd Lake Dam
MO ID 30744

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END

DATE
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